ceptually straightforward (see figure). By use of a conventional illumination-type fiber-optic bundle, visible light from a source outside a cryostat is fed into the cryostat to back-illuminate the scale. In a typical case, an image of the scale can be acquired and fed to the CCD optics by use of a lens-tipped coherent fiber-optic bundle similar to a fiber-optic borescope or endoscope. A low-thermal-conductivity hermetic feedthrough is installed at the point where the fiber-optic bundle passes through the cryostat wall. Alternately, an image of the scale can be projected out through a small window in the cryostat wall. Either way, the encoding function involves very little energy dissipation inside the cryostat.

This work was done by Douglas B. Leviton of **Goddard Space Flight Center**. *Further information is contained in a TSP (see page 1).*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center, (301) 286-7351. Refer to GSC-14766-1.

Inter-Valence-Subband/Conduction-Band-Transport IR Detectors

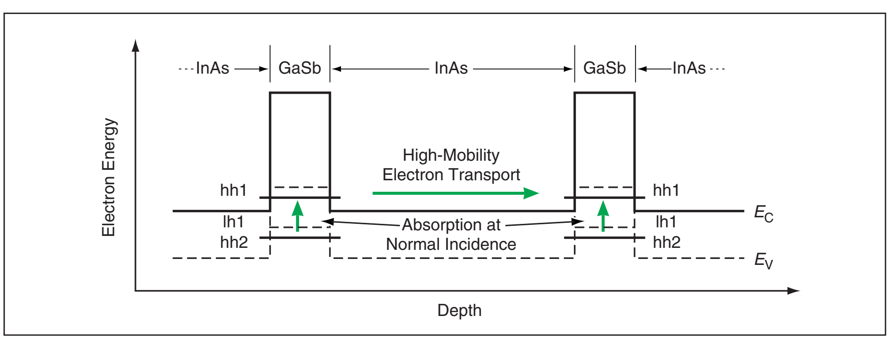
These devices would be capable of operation at normal incidence.

NASA's Jet Propulsion Laboratory, Pasadena, California

Infrared (IR) detectors characterized by a combination of (1) high-quantum-efficiency photoexcitation of inter-valence-subband transitions of charge carriers and (2) high-mobility conduction-band transport of the thus-excited charge carriers have been proposed in an effort to develop focal-plane arrays of such devices for infrared imaging. Like many prior quantum-well infrared photodetectors (QWIPs), the proposed devices would be made from semiconductor heterostructures. In order to obtain the combination of characteristics mentioned above, the proposed devices would be designed and fabricated in novel InAs/GaSb superlattice configurations that would exploit a phenomenon known in the semiconductor art as type-II broken-gap band offset.

Previously tested GaInSb/InAs type-II strained-layer-superlattice devices have shown the potential to offer optical properties comparable to, degrees of uniformity greater than, and tunneling currents and Auger recombination less than, those of HgCdTe IR photodetectors. Moreover, the GaInSb/InAs type-II strained-layer devices have been shown to be capable of operation at normal incidence. The operation of the GaInSb/InAs type-II strained-layer devices involves transitions from valence subbands in GaInSb to conduction subbands in InAs. The spatial separation of wave functions involved in the transition results in reduced oscillator strengths. Therefore, to obtain adequate quantum efficiency, it is necessary to grow thick, high-quality superlattices — a task that is challenging because GaInSb and InAs are lattice-mismatched. The development of the proposed devices would implement an alternative approach to exploitation of some of the same basic principles as those of the GaInSb/InAs type-II strained-layer devices.

It is useful to compare the proposed GaSb/InAs QWIPs with prior GaAs/AlGaAs QWIPs, which utilize n doping. Because quantum-mechanical selection rules in n-doped QWIPs forbid inter-conduction-subband transitions induced by normally incident light, optical coupling gratings are needed to achieve acceptable quantum efficiencies in such QWIPs. On the other hand, inter-valence-subband transitions in p-doped QWIPs can absorb normally incident photons with high quantum efficiency, so that optical coupling gratings are not needed.



This **Energy-Band Diagram of a GaSb/InAs QWIP** depicts the energy levels involved in the exploitation of (1) inter-valence-subband transitions in GaSb for detection and (2) transport in the InAs conduction band. The relevant energy bands and the energies at their edges are denoted as follows: EC for conduction band; EV for valence band; hh1 and hh2 for heavy-hole bands 1 and 2, respectively; and lh1 for light-hole band 1.

An InAs/GaSb multi-quantum well structure according to the proposal would comprise p-doped GaSb quantum wells embedded in InAs barriers (see figure). The inter-valence-subband transitions in the GaSb wells would absorb normally incident photons with high quantum efficiency. Although the InAs layers would be barriers to ground-state electrons, a device of this type would take advantage of the high electron mobility in the InAs conduction band for transporting excited electrons between the GaSb quantum wells. This would be made possible by the type-II broken-gap band offset between InAs and GaSb: The edge of the valence band of GaSb is approximately 0.15 eV higher than the conduction-band edge of InAs. Therefore, electrons in the p-doped GaSb quantum wells that were photoexcited to the uppermost subband (denoted the heavy-hole 1 or hh1 subband) could easily escape into the conduction band in InAs layers.

This work was done by David Ting, Sarath Gunapala, and Sumith Bandara of Caltech for **NASA's Jet Propulsion** *Laboratory. Further information is con*tained in a TSP (see page 1).

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